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Kambara et al.

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(54) **SEWING MACHINE**

(71) Applicant: **JANOME SEWING MACHINE CO., LTD.**, Tokyo (JP)

(72) Inventors: **Yumiko Kambara**, Tokyo (JP); **Yoshitaka Bamba**, Tokyo (JP); **Jun Mafune**, Tokyo (JP)

(73) Assignee: **JANOME SEWING MACHINE CO., LTD.**, Tokyo (JP)

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(51) **Int. Cl.**
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D05B 73/12 (2006.01)

(52) **U.S. Cl.**
CPC ***D05B 37/08*** (2013.01); ***D05B 73/12*** (2013.01)

(58) **Field of Classification Search**
CPC D05B 73/12; D05B 37/063; D05B 37/08
See application file for complete search history.

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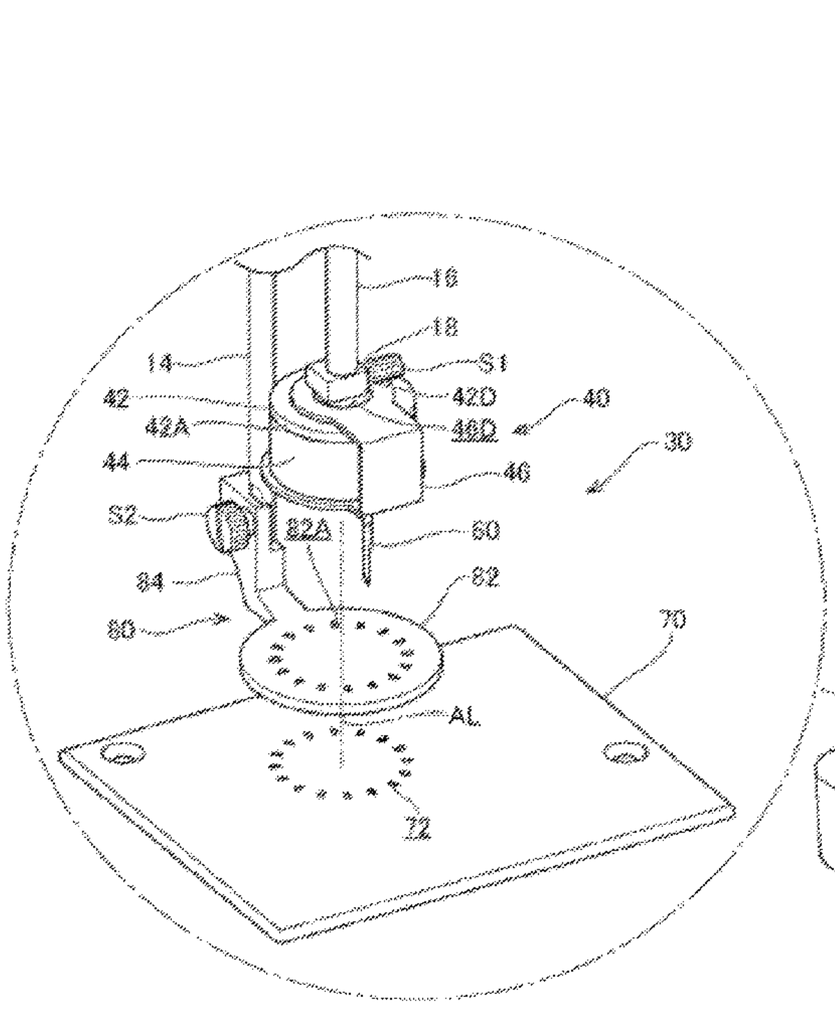
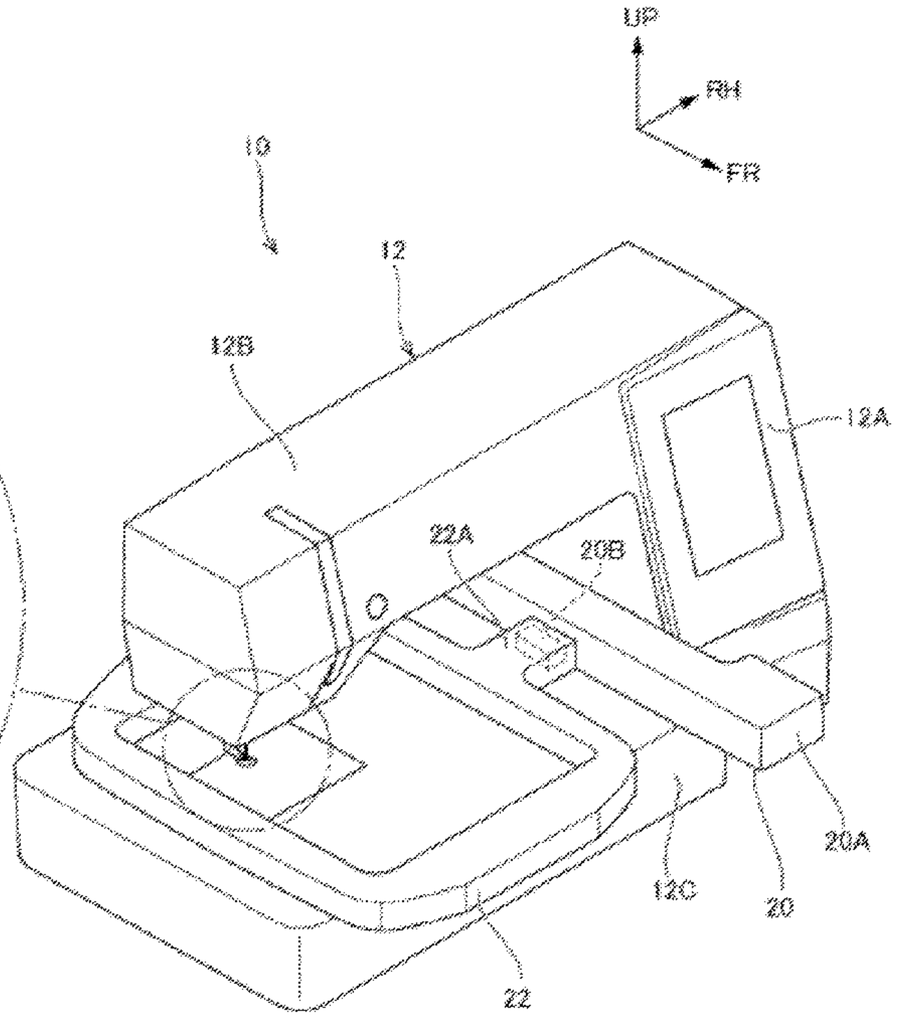
Primary Examiner — Nathan E Durham
(74) *Attorney, Agent, or Firm* — Nakanishi IP Associates, LLC

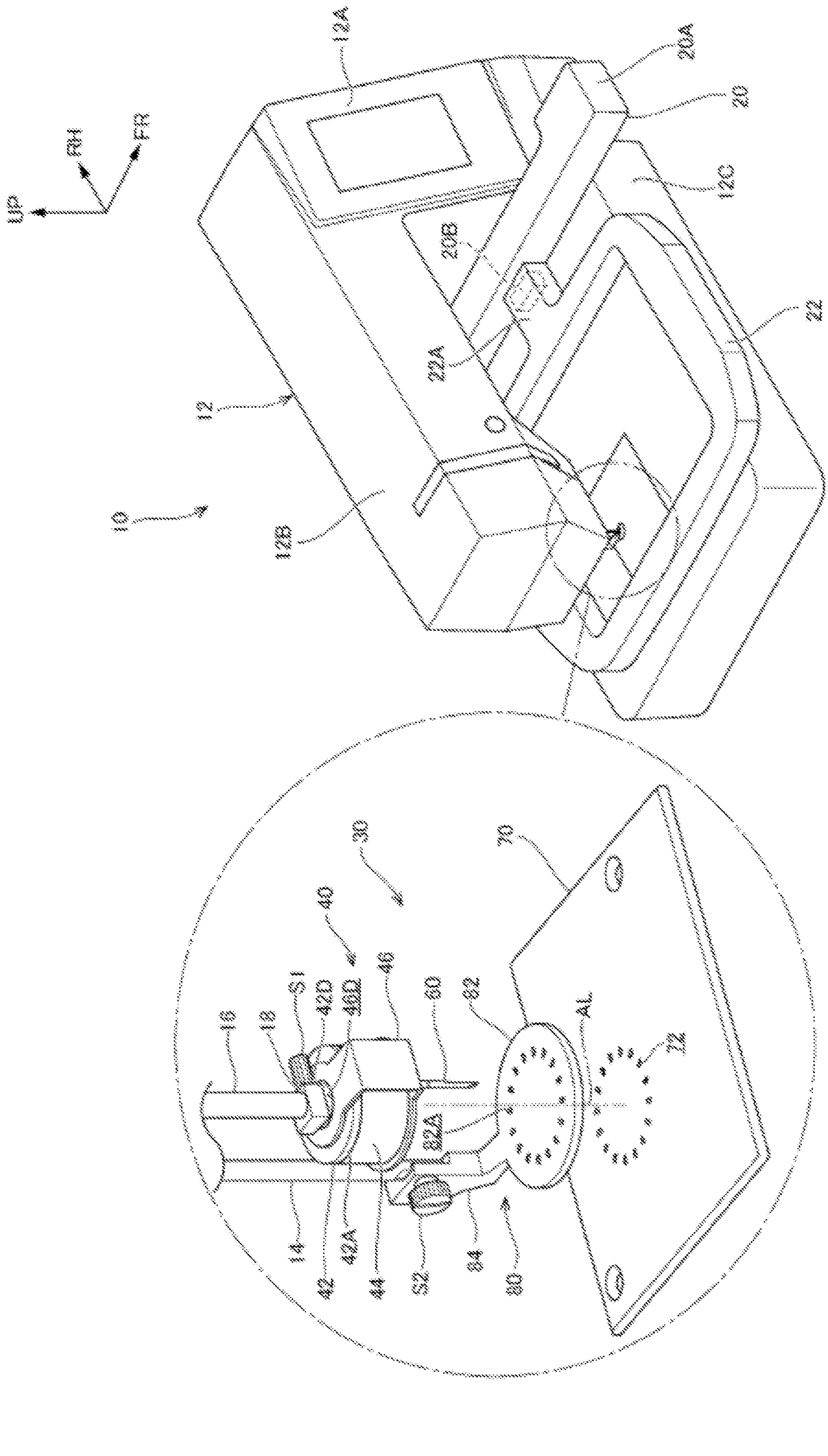
(57) **ABSTRACT**

In a sewing machine, a plurality of needle plate holes are formed in a needle plate. The needle plate holes are arranged at positions respectively corresponding to a plurality of blade-side rotation positions of a cutwork blade. In this manner, the needle plate hole is formed in a shape corresponding to a shape of a blade portion, and a direction of the needle plate hole can match a direction of the blade portion that is arranged above to face the needle plate hole. Specifically, a linear hole-side cutting surface corresponding to a blade-side cutting surface of the blade portion is formed in the needle plate hole, and the blade-side cutting surface and the hole-side cutting surface can be arranged to face each other in a direction orthogonal to both the surfaces in a plan view.

6 Claims, 8 Drawing Sheets



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AL
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S2
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Fig.1

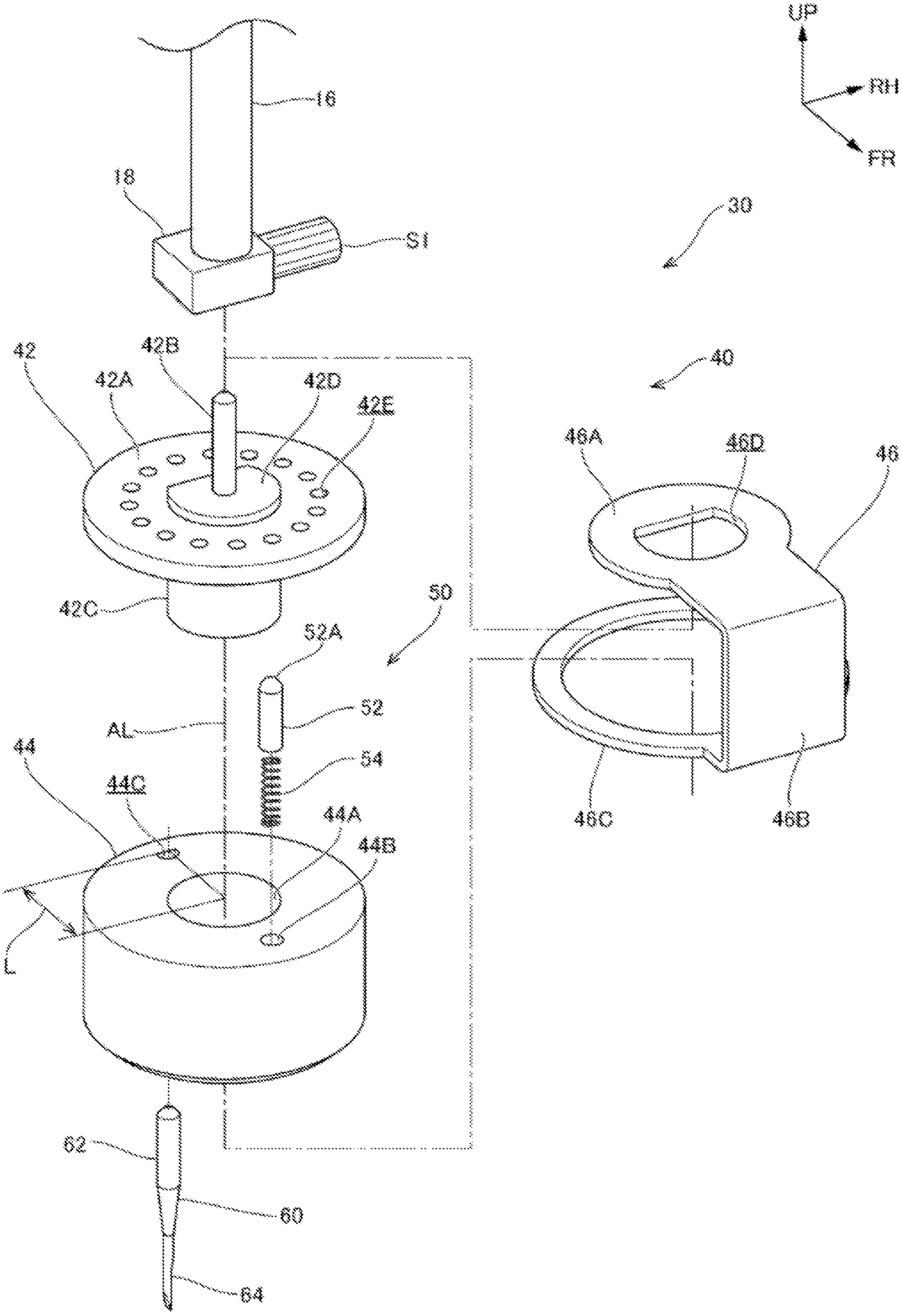
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Fig.2

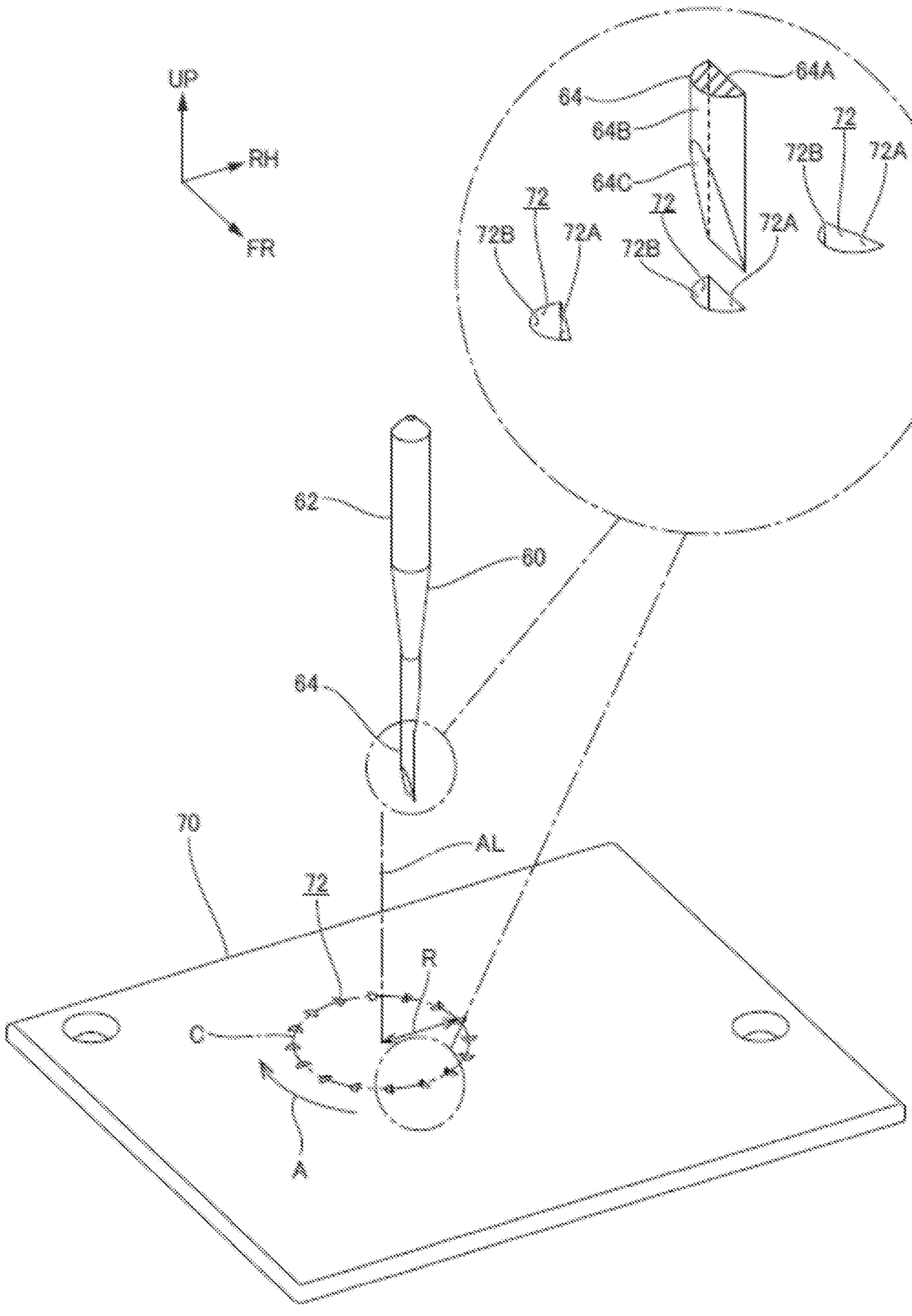
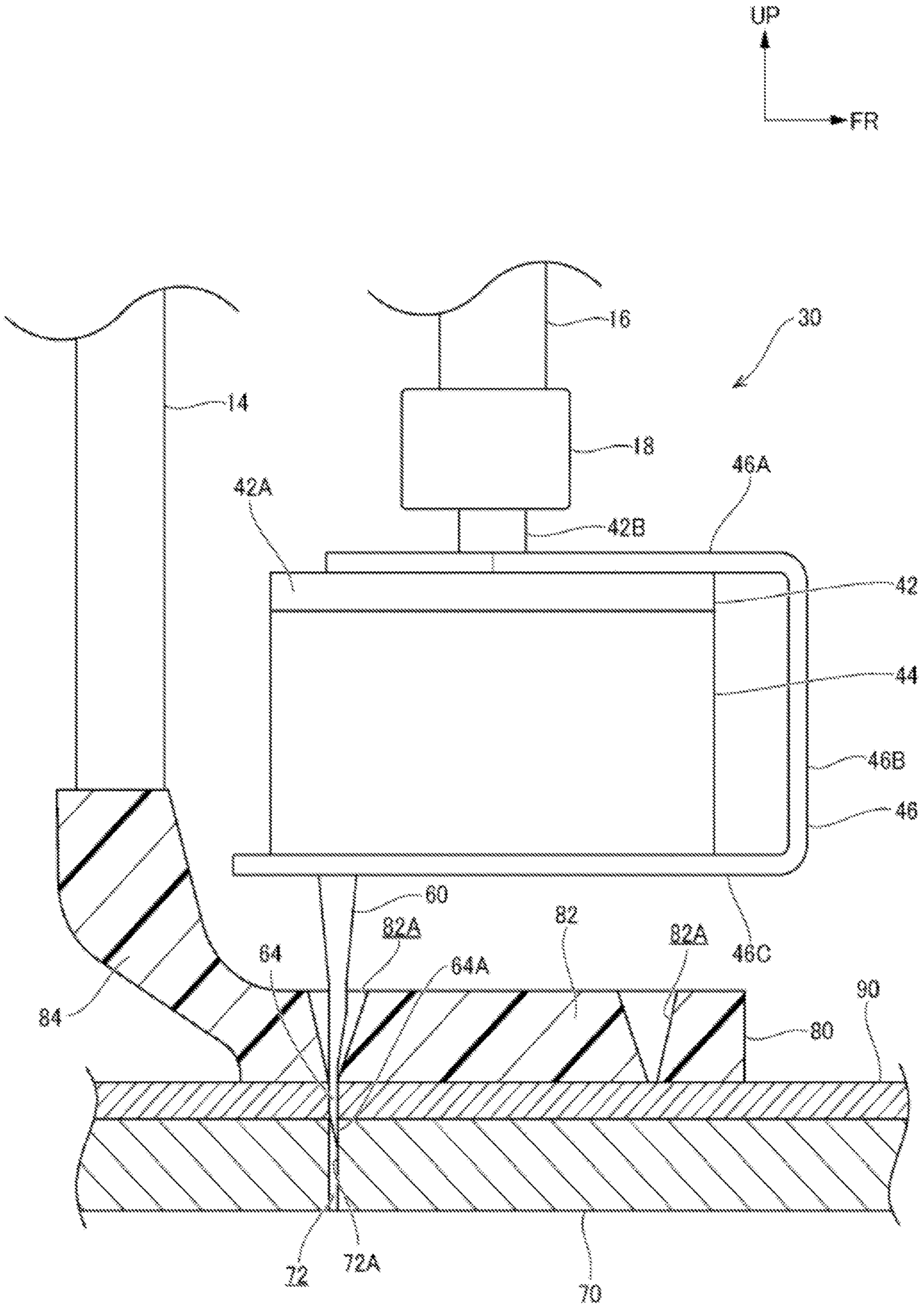


Fig.3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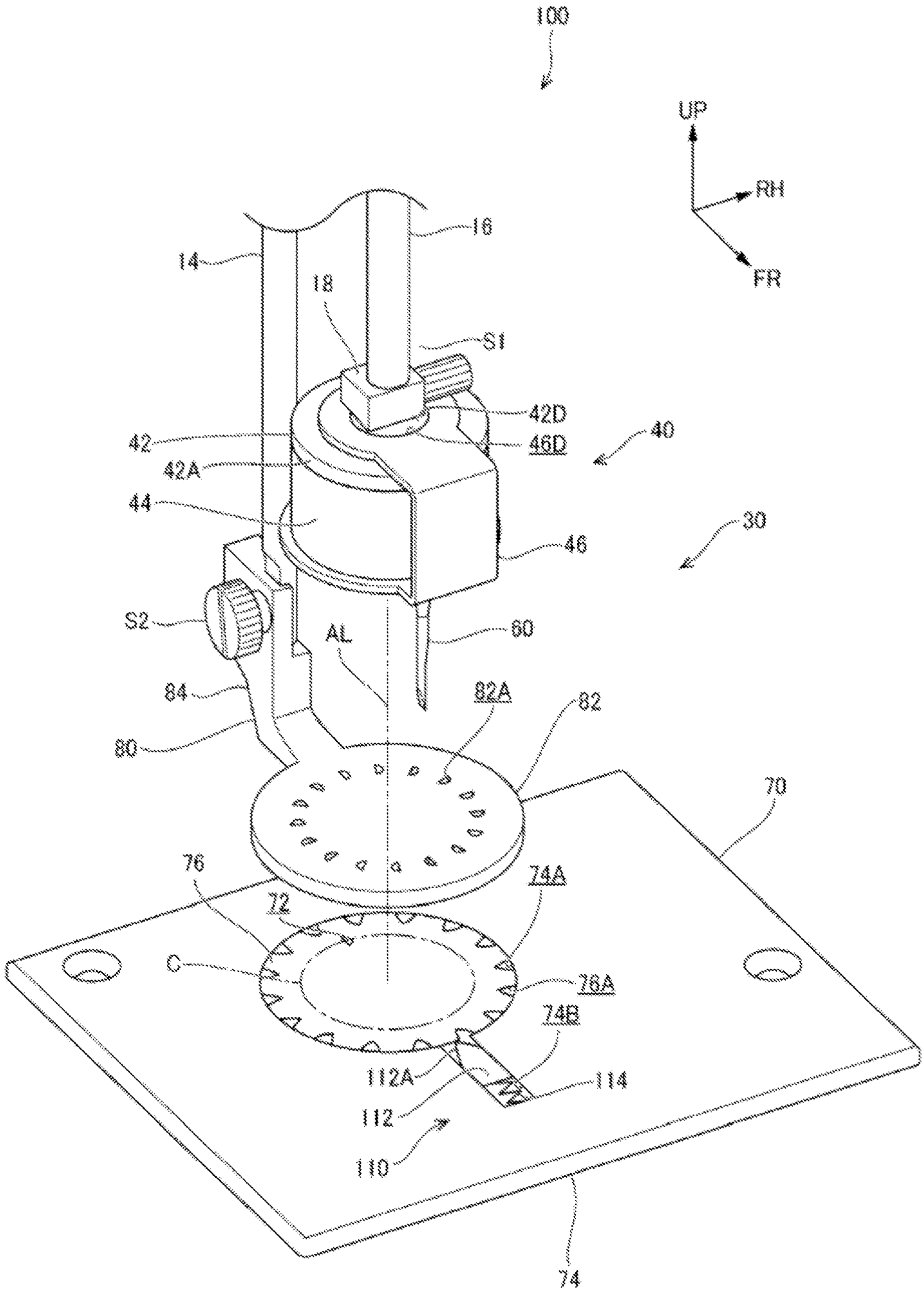
72A
70

Fig.4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74B
112A
114
112
110
74

Fig.5

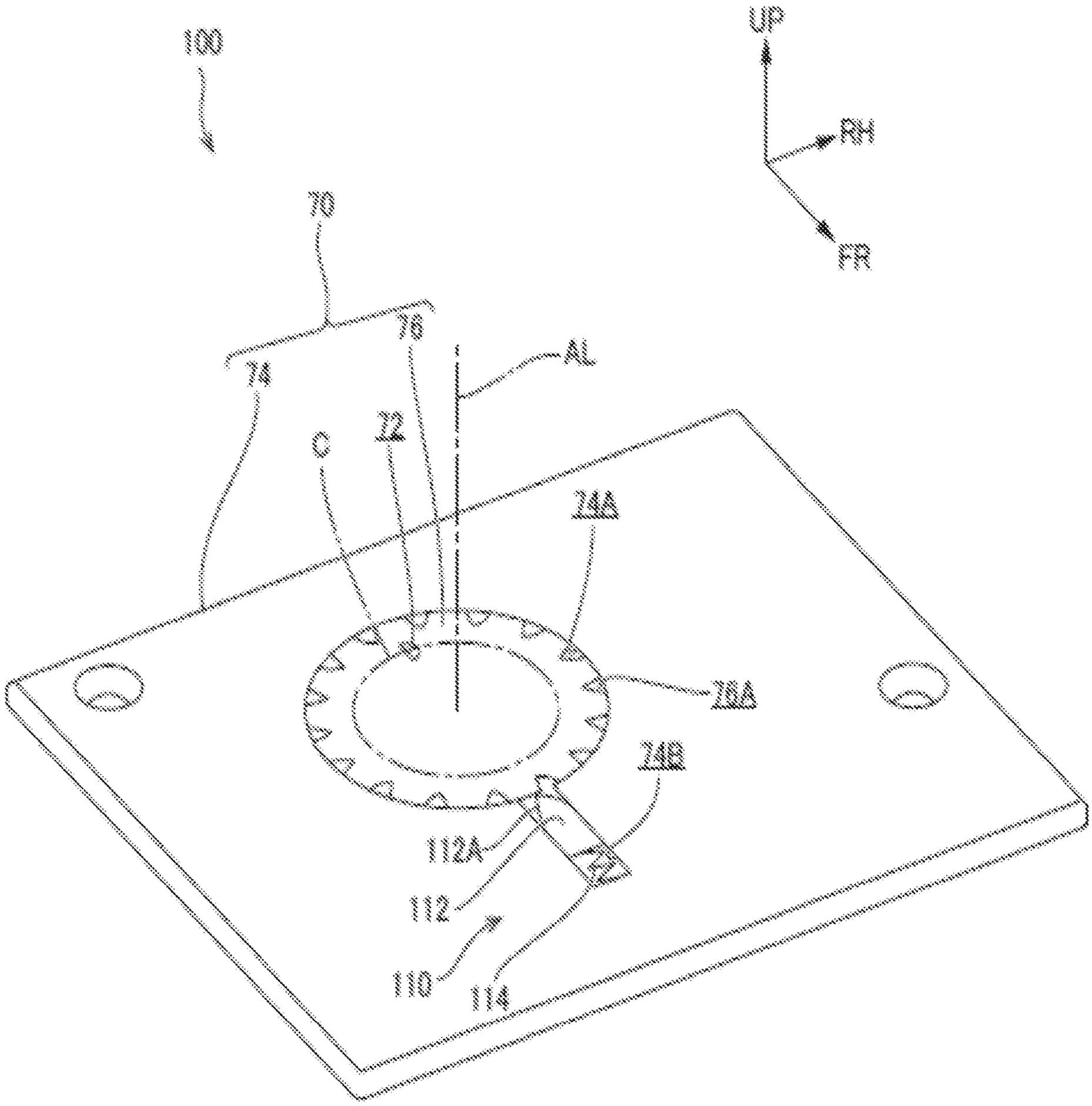
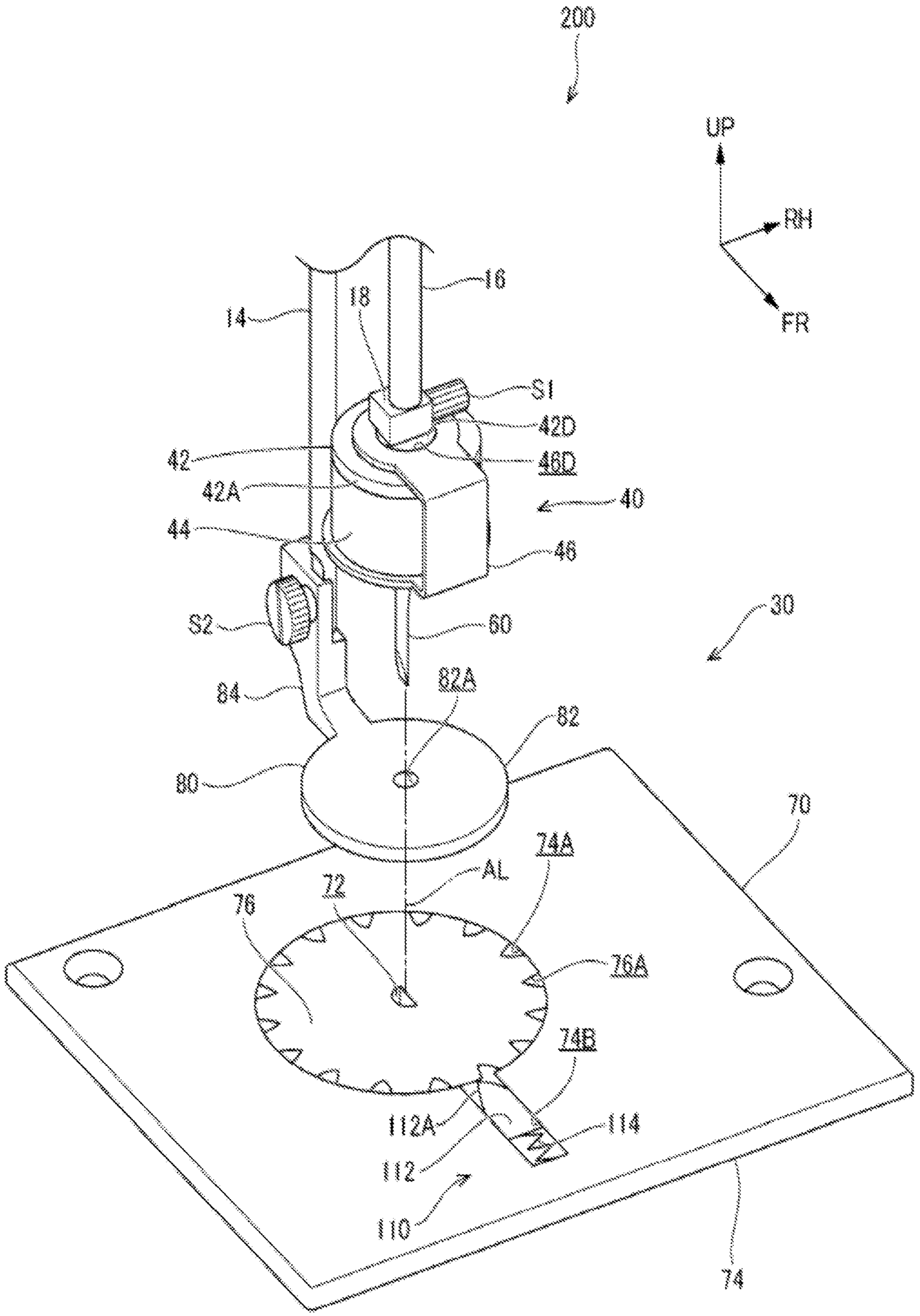


Fig.6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UP
RH
FR
16
18
14
S1
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46D
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42A
40
44
46
S2
60
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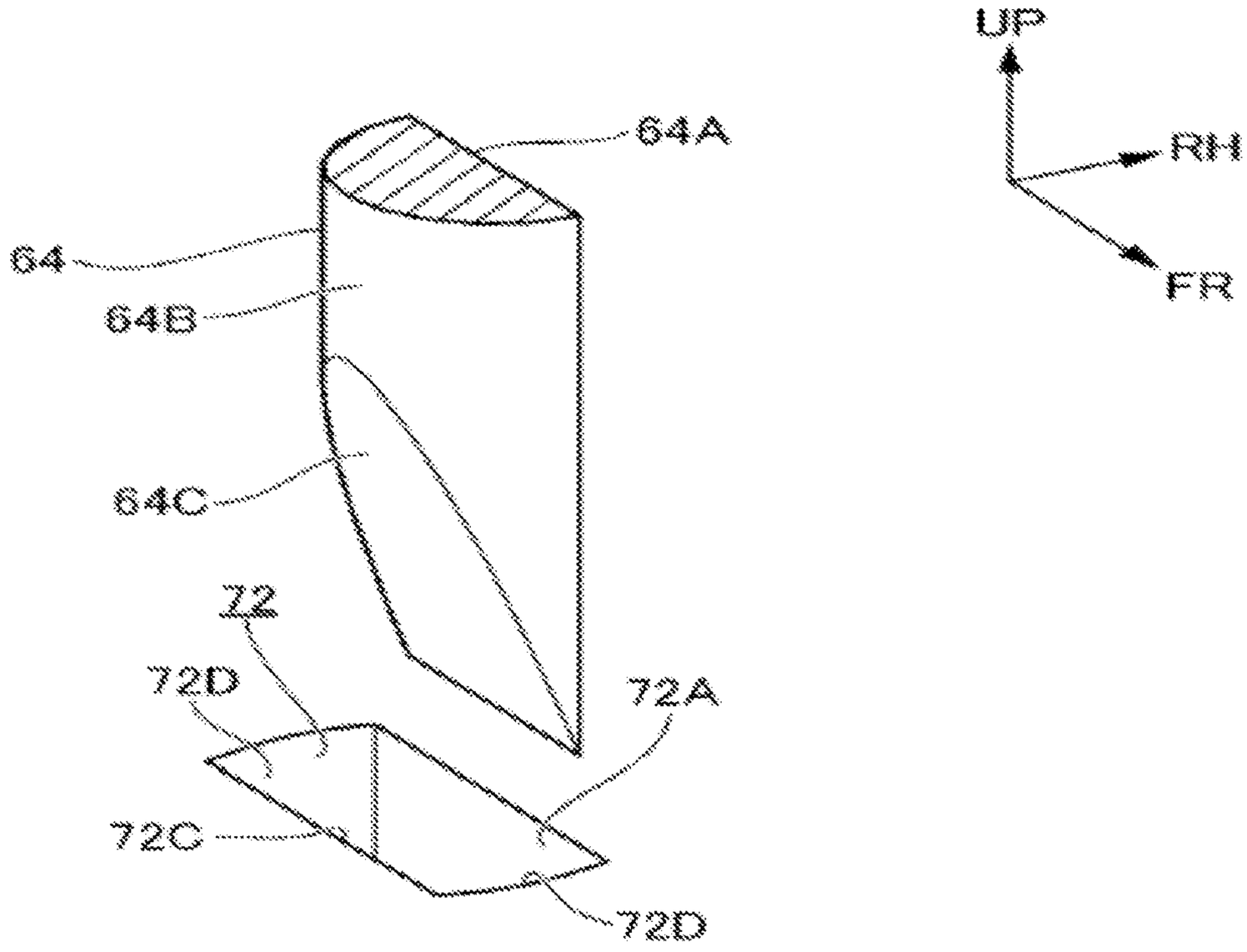
76A
74B
112A
114
112
110
74

Fig.7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64B
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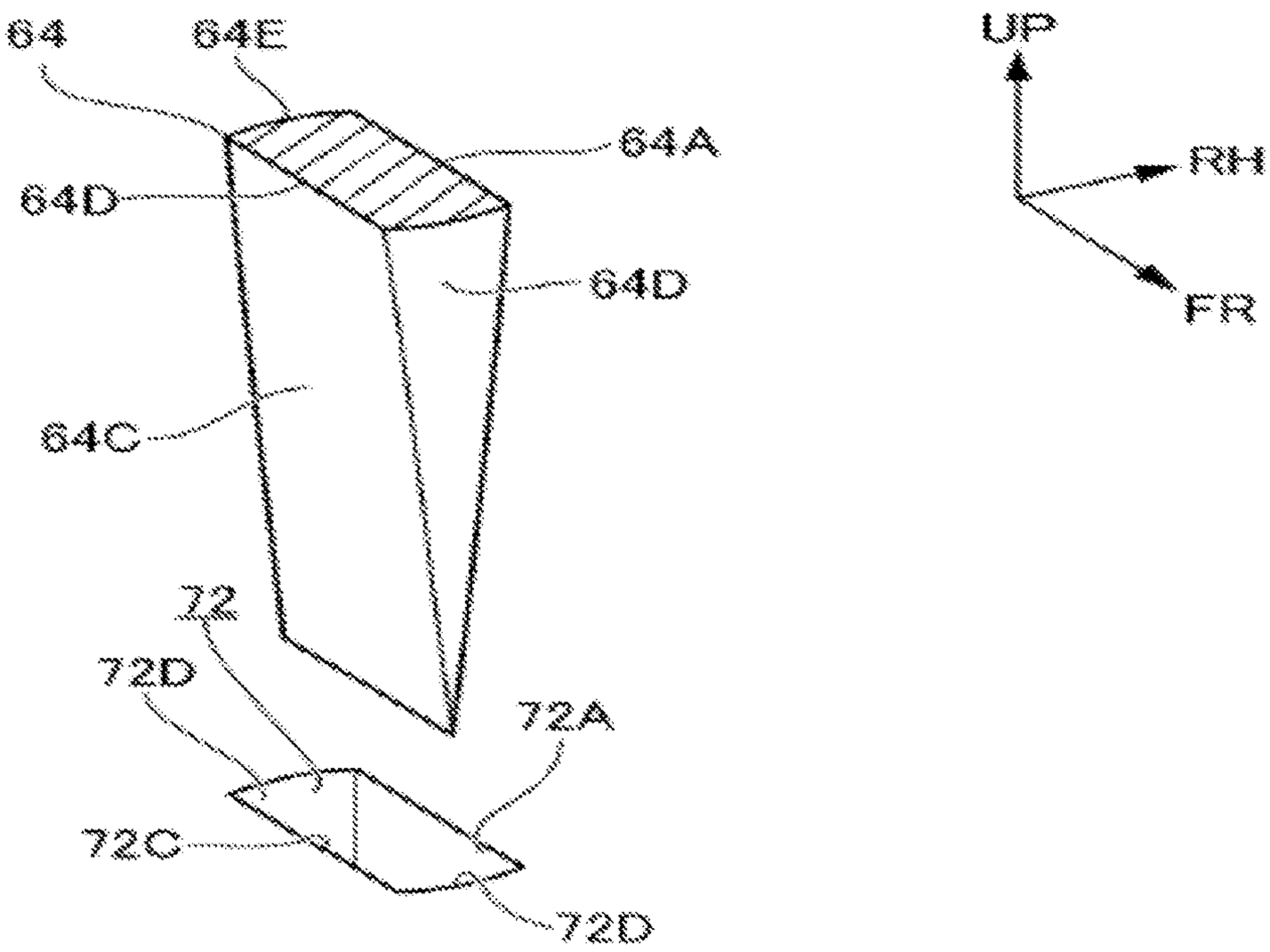
72A
72C
72D
UP
RH
FR

FIG.8A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64E
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64D
64D
64C
72
72D
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72C
72D
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RH
FR

FIG.8B

SEWING MACHINE

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority to Japanese Patent Application No. 2020-019495 filed on Feb. 7, 2020, the entire content of which is incorporated by reference.

BACKGROUND OF THE INVENTION

Field of the Invention

The invention relates to a sewing machine.

Background Art

JP-A-2014-195491 discloses a sewing machine that can form a patent or the like on a cutting target object (cloth) by cutting the cutting target object. Specifically, a cutting needle rotation device is provided on a lower end portion of a needle bar, a cutting needle (cutwork blade) of the cutting needle rotation device is arranged coaxially with the needle bar, and is configured to be rotatable around the axis of the needle bar. Further, a needle plate is provided below the cutting needle rotation device, and a needle plate hole is formed in the needle plate. The cutting needle is lowered together with the needle bar so that a blade portion of the cutting needle is inserted into the needle plate hole, and thereby the cutting target object is cut by the blade portion and the needle plate hole.

SUMMARY OF THE INVENTION

However, in the sewing machine in JP-A-2014-195491, there is room for improvement in the following points. That is, in the above-described sewing machine, since the cutting needle is rotated around the axis of the needle bar, the direction of the cutting needle is changed according to the rotation position of the cutting needle. In JP-A-2014-195491, the shape of the needle plate hole is not particularly mentioned, but generally, the needle plate hole is formed in a circular shape in order to cope with the change of the direction of the cutting needle. Therefore, when the cutting target object is cut, the cutting target object may be torn off, and the cut portion may be formed on a rough surface. In this manner, in the above-described sewing machine, there is room for improvement in improving the finish of the cut portion.

An object of the invention is to provide a sewing machine which can improving the finish of the cut portion in consideration of the above circumstances.

One or more embodiments of the invention are a sewing machine including a rotation mechanism configured to include a base attached to a lower end portion of a needle bar that is moved up and down, and a rotation body connected to the base to be rotatable around an axis of the needle bar; a cutwork blade which is provided on the rotation body, and extends downward from the rotation body; and a needle plate which is provided below the rotation mechanism, and has a needle plate hole for cutting a cutting target object in cooperation with a blade portion of the cutwork blade when the blade portion is inserted into the needle plate hole, in which the blade portion is inserted into the needle plate hole in a state where a direction of the needle plate hole matches the blade portion of the cutwork blade.

One or more embodiments of the invention are the sewing machine in which the rotation body is locked at every predetermined rotation angle by the lock mechanism, the cutwork blade is arranged at a position apart from an axis line of the needle bar, and a plurality of the needle plate holes are formed around the axis line of the needle bar at the same angle as the predetermined angle of the lock mechanism, on a reference circle having, as a radius, the same distance as a distance between the axis line of the needle bar and the cutwork blade.

One or more embodiments of the invention are the sewing machine in which the rotation body is locked at every predetermined rotation angle by the lock mechanism, and the needle plate is configured to include a needle plate body fixed to the sewing machine body, and a rotary needle plate which is connected to the needle plate body to be rotatable around the axis of the needle bar, and is able to be locked at every angle that is the same as the predetermined angle of the lock mechanism, and in which the needle plate hole is formed.

One or more embodiments of the invention are the sewing machine in which the cutwork blade is arranged coaxially with the needle bar.

One or more embodiments of the invention are the sewing machine in which the cutwork blade and the needle plate hole are arranged at positions apart from the axis line of the needle bar by the same distance.

One or more embodiments of the invention are the sewing machine in which the blade portion has a blade-side cutting surface that is linearly formed when seen from an axial direction of the needle bar, and the needle plate hole has a hole-side cutting surface that is formed in a flat surface shape, corresponding to the blade-side cutting surface.

According to the sewing machine having the above-described configuration, the finish of the cut portion can be improved.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a perspective view illustrating a sewing machine according to a first embodiment, which is seen diagonally from the front left.

FIG. **2** is an exploded perspective view in which a cutwork mechanism illustrated in FIG. **1** is exploded.

FIG. **3** is a perspective view illustrating a needle plate and a cutwork blade illustrated in FIG. **1** in an enlarged manner.

FIG. **4** is a vertical sectional view schematically illustrating a state in which a cutting target object is cut by the cutwork blade and a needle plate hole of the needle plate illustrated in FIG. **1**.

FIG. **5** is a perspective view illustrating a main part of a sewing machine according to a second embodiment, which is seen diagonally from the front left.

FIG. **6** is a perspective view illustrating a needle plate illustrated in FIG. **5** in an enlarged manner.

FIG. **7** is a perspective view illustrating a main part of a sewing machine according to a third embodiment, which is seen diagonally from the front left.

FIG. **8**A is a perspective view illustrating a modification example of the needle plate hole illustrated in FIG. **3**, and FIG. **8**B is a perspective view illustrating another modification example of the blade portion of the cutwork blade and the needle plate hole illustrated in FIG. **3**.

DETAILED DESCRIPTION OF THE INVENTION

First Embodiment

Hereinafter, a sewing machine **10** according to a first embodiment will be described using FIGS. **1** to **4**. Arrows UP, FR, and RH appropriately illustrated in the drawings indicate the upper side, the front side, and the right side (one side in a width direction) of the sewing machine **10**, respectively. Hereinafter, in a case where description is made using the up-down direction, the front-rear direction, and the left-right direction, those directions indicate the up and down, the front and rear, and the left and right of the sewing machine **10**.

As illustrated in FIG. **1**, the sewing machine **10** has a sewing machine body **12**, and the sewing machine body **12** is formed in a substantially U shape open leftward in a front view seen from the front side. Specifically, the sewing machine body **12** is configured to include a pillar portion **12**A that constitutes a right end portion of the sewing machine body **12** and extends in the up-down direction, an arm portion **12**B that extends to the left side from the upper end portion of the pillar portion **12**A, and a bed portion **12**C that extends to the left side from the lower end portion of the pillar portion **12**A.

A presser bar **14** that extends in the up-down direction is provided inside a left end portion of the arm portion **12**B, and a lower end portion of the presser bar **14** protrudes downward from the arm portion **12**B. The presser bar **14** is supported by an operation lever (not illustrated), and is configured to be moved in the up-down direction by operating the operation lever.

Further, a substantially columnar needle bar **16** of which the axial direction is the up-down direction is provided in front of the presser bar **14**. The upper end portion of the needle bar **16** is provided inside the arm portion **12**B, and the lower end portion of the needle bar protrudes downward from the arm portion **12**B. The needle bar **16** is connected to a needle bar drive mechanism (not illustrated), and the needle bar **16** is moved in the up-down direction in a reciprocating manner by the needle bar drive mechanism during the operation of the sewing machine **10**. Further, a needle bar fixing portion **18** for fixing a base **42**, which will be described later, is provided on the lower end portion of the needle bar **16**. A fixing hole (not illustrated) is formed in the needle bar fixing portion **18**, and the fixing hole is open downward, and is formed to have a substantially D-shaped cross section.

The sewing machine **10** is configured as a sewing machine that can perform cutting on a cutting target object **90** (refer to FIG. **4**) such as cloth. Specifically, the sewing machine **10** has an embroidery frame drive device **20**, an embroidery frame **22**, a needle plate **70**, a presser **80**, and a cutwork mechanism **30** which are used during cutting. Hereinafter, each configuration of the sewing machine **10** used during cutting will be described.

Regarding Embroidery Frame Drive Device **20**

The embroidery frame drive device **20** is detachably mounted on the bed portion **12**C of the sewing machine body **12**. The embroidery frame drive device **20** is configured to include a drive arm **20**A and a carriage **20**B. The drive arm **20**A is formed in a substantially rectangular parallelepiped shape extending in the front-rear direction, and is configured to be movable in the left-right direction, on a side above the bed portion **12**C. The carriage **20**B is provided on the drive arm **20**A so as to be movable in the front-rear direction. The drive arm **20**A and the carriage **20**B are configured to be moved by a drive unit (not illustrated) of the embroidery frame drive device **20**.

Regarding Embroidery Frame **22**

The embroidery frame **22** is formed in a substantially rectangular frame shape. An embroidery frame fixing portion **22**A protruding rightward is formed on the right outer circumferential portion of the embroidery frame **22**, and the embroidery frame fixing portion **22**A is fixed to the carriage **20**B of the embroidery frame drive device **20**. In this manner, the embroidery frame **22** is configured to be moved in the front-rear and left-right directions, on a side below the needle bar **16**, by driving the embroidery frame drive device **20**. In addition, the embroidery frame **22** is configured by two members, and the embroidery frame **22** is configured to vertically sandwich the cutting target object **90**. In this manner, the cutting target object **90** is configured to be movable in the front-rear and left-right directions together with the embroidery frame **22**, on a side below the needle bar **16** and above the bed portion **12**C.

Regarding Cutwork Mechanism **30**

As illustrated in FIGS. **1** and **2**, the cutwork mechanism **30** is configured to include a rotation mechanism **40**, a lock mechanism **50**, and a cutwork blade **60**.

Regarding Rotation Mechanism **40**

The rotation mechanism **40** has the base **42**, a rotation body **44**, and a bracket **46**.

The base **42** has a base plate **42**A, and the base plate **42**A is formed in a substantially disk shape of which the plate thickness direction is the up-down direction. A base fixing shaft **42**B protruding upward is formed at a central portion of the base plate **42**A, and the base fixing shaft **42**B is formed in a substantially D shape in a plan view. The base fixing shaft **42**B is mounted to the fixing hole of the needle bar fixing portion **18** from below, and is fixed to the needle bar fixing portion **18** by a fixing screw S**1**. In this manner, the base **42** is connected to the needle bar **16** so as not to be relatively movable.

The base **42** has a connection pillar **42**C for connecting the rotation body **44** which will be described later. The connection pillar **42**C is formed in a substantially columnar shape of which the axial direction is the up-down direction, extends downward from the base plate **42**A, and is arranged coaxially with the needle bar **16**.

A fitting portion **42**D protruding upward is formed at a substantially central portion on the upper surface of the base plate **42**A. The fitting portion **42**D is formed in a substantially D shape in a plan view.

Further, a plurality of (**16** in the embodiment) circular lock holes **42**E are formed to penetrate the base plate **42**A, on the outer side of the connection pillar **42**C and the fitting portion **42**D in a radial direction. The lock holes **42**E are arranged on an imaginary circle centering on an axis line AL of the needle bar **16**, and are arranged at equal intervals (every 22.5 degrees) around the axis line AL. The lock holes **42**E constitute a part of the lock mechanism **50** which will be described later.

The rotation body **44** is formed in a substantially bottomed cylindrical shape which is open upward. Specifically, a connection recess **44**A open upward is formed at the central portion of the rotation body **44**, and the connection recess **44**A is formed in a circular shape in a plan view. Then, the connection pillar **42**C of the base **42** is inserted into the connection recess **44**A from above, and the rotation body **44** is rotatably supported by the connection pillar **42**C. That is,

the rotation body **44** is arranged coaxially with the needle bar **16**, and is connected to the base **42** so as to be rotatable around the axis line AL.

An accommodation recess **44**B for accommodating a lock pin **52**, which will be described later, is formed on the upper surface of the rotation body **44**. The accommodation recess **44**B is formed in a recess shape open upward, and is formed in a circular shape in a plan view. Further, in a plan view, the distance from the axis line AL to the accommodation recess **44**B and the distance from the axis line AL to the lock hole **42**E are the same. In this manner, the accommodation recess **44**B and the lock hole **42**E are configured to be arranged to face each other in the up-down direction, at a specific rotation position of the rotation body **44**. The position of the rotation body **44** where the accommodation recess **44**B and the lock hole **42**E are arranged to face each other in the up-down direction is referred to as a rotation body lock position. That is, in the embodiment, 16 rotation body lock positions of the rotation body **44** are set around the axis line AL.

Further, a fixing hole **44**C for fixing the cutwork blade **60**, which will be described later, is formed to penetrate the rotation body **44** in the up-down direction. The fixing hole **44**C is formed in a substantially D shape in a plan view, and is arranged 180 degrees apart from the accommodation recess **44**B in the circumferential direction (rotation direction) of the rotation body **44**.

The bracket **46** is formed in a substantially U-shaped plate shape open rearward, in a side view seen from the left-right direction. Specifically, the bracket **46** is configured to include an upper wall **46**A, a front wall **46**B extending downward from the front end portion of the upper wall **46**A, and a lower wall **46**C extending rearward from the lower end portion of the front wall **46**B.

The upper wall **46**A is arranged adjacent to the upper side of the base plate **42**A of the base **42**, and the lower wall **46**C is arranged adjacent to the lower side of the rotation body **44** so that the base **42** and the rotation body are sandwiched by the bracket **46** in the up-down direction. In this manner, the downward movement of the rotation body **44** is restricted by the bracket **46**.

A fitting hole **46**D is formed to penetrate the upper wall **46**A. The fitting hole **46**D is formed in a substantially D shape in a plan view, corresponding to the fitting portion **42**D of the base **42**. The fitting portion **42**D is fitted into the fitting hole **46**D. In this manner, the rotation of the bracket **46** around the axis line AL relative to the base **42** is restricted.

The lower wall **46**C is formed in a substantially annular plate shape, and is arranged coaxially with the needle bar **16**. The outer diameter of the lower wall **46**C is set to be greater than the outer diameter of the rotation body **44**. Further, the inner diameter of the lower wall **46**C is set to be greater than a distance L from the axis line AL to the fixing hole **44**C. That is, the fixing hole **44**C is arranged inward of the lower wall **46**C when seen from below.

Regarding Lock Mechanism **50**

The lock mechanism **50** is configured as a mechanism that locks (prevents) the rotation of the rotation body **44**. The lock mechanism **50** is configured to include the lock holes **42**E formed on the base **42**, the lock pin **52**, and an urging spring **54**.

The lock pin **52** is formed in a substantially columnar shape of which the axial direction is the up-down direction. The lock pin **52** is inserted into the accommodation recess **44**B of the rotation body **44** so as to be relatively movable in the up-down direction. The upper end portion of the lock pin **52** is configured as an engaging portion **52**A, and the engaging portion **52**A is formed in a hemispherical shape that is convex upward. Further, the diameter of the lock pin **52** is set to be greater than the diameter of the lock hole **42**E of the base **42**.

The urging spring **54** is configured as a compression coil spring. The urging spring **54** is accommodated in the accommodation recess **44**B together with the lock pin **52** in a state of being compressed and deformed. Specifically, the urging spring **54** is arranged below the lock pin **52**, the lower end portion of the urging spring **54** is locked to the bottom surface of the accommodation recess **44**B, and the upper end portion of the urging spring **54** is locked to the lower surface of the lock pin **52**. In this manner, the lock pin **52** is urged upward by the urging spring **54**.

At the rotation body lock position of the rotation body **44**, the top of the engaging portion **52**A of the lock pin **52** is arranged in the lock hole **42**E, and the engaging portion **52**A is in contact with the edge portion of the lock hole **42**E, so that the lock pin **52** and the lock hole **42**E are engaged with each other. In this manner, the rotation of the rotation body **44** is locked (prevented).

Further, at the rotation body lock position of the rotation body **44**, the lock state of the rotation body **44** by the lock mechanism **50** is released by applying rotational force equal to or greater than a predetermined value to the rotation body **44**. That is, by applying the rotational force equal to or greater than the predetermined value to the rotation body **44**, the lock pin is moved downward against the urging force of the urging spring **54**, and thereby the engaged state between the lock pin **52** and the lock hole **42**E is released. Then, the lock pin **52** is engaged with the lock hole **42**E again by relatively rotating the rotation body **44** to the next rotation body lock position, and thereby the rotation body returns to the lock state by the lock mechanism **50**. That is, the rotation body **44** is configured to be locked at every predetermined rotation angle (22.5 degrees in the embodiment) by the lock mechanism **50**.

Regarding Cutwork Blade **60**

As illustrated in FIG. **3**, the cutwork blade **60** is formed in a substantially bar shape of which the axial direction is the up-down direction. The upper portion of the cutwork blade **60** is configured as a blade-side fixing portion **62**, and the blade-side fixing portion **62** is formed in a substantially D shape corresponding to the fixing hole **44**C of the rotation body **44** in a plan view. The blade-side fixing portion **62** is fitted into the fixing hole **44**C of the rotation body **44** from below, so that the cutwork blade **60** is fixed to the rotation body **44**. In this manner, in a state where the rotation of the cutwork blade **60** relative to the rotation body **44** is restricted, the cutwork blade **60** is arranged at a position apart (eccentric) from the axis line AL by the distance L in a plan view. That is, the cutwork blade **60** is configured to be rotated around the axis line AL at a position eccentric with respect to the axis line AL by the rotating the rotation body **44** around the axis line AL. In the following description, the position of the cutwork blade **60** at the rotation body lock position of the rotation body **44** is referred to as a blade-side rotation position. In this manner, in the cutwork mechanism **30**, a plurality of (**16** in the embodiment) blade-side rotation positions are set around the axis line AL, and the cutwork blade **60** is configured to be held at a specific blade-side rotation position by the lock mechanism **50**.

The lower end portion of the cutwork blade **60** is configured as a blade portion **64** for cutting the cutting target object **90**. The blade portion **64** is formed in a substantially D shape when seen from below. Specifically, the blade portion **64** is

configured to include a blade-side cutting surface **64**A extending linearly in the radial direction of the rotation body **44** in a plan sectional view, and a blade-side curved surface **64**B which is curved in a substantially arc shape to be convex to one side around the axis line AL (which is a direction of an arrow A in FIG. **3**, and is one side of the rotation direction of the rotation body **44**) in a plan sectional view. Further, in the blade portion **64**, the blade-side cutting surface **64**A mainly has a function of cutting the cutting target object **90**. That is, the cutwork blade **60** is formed in a non-circular shape including at least a linear portion constituting the blade-side cutting surface **64**A in a plan sectional view.

Further, an inclined surface **64**C is formed on the lower end portion of the blade-side curved surface **64**B of the blade portion **64**. The lower end of the inclined surface **64**C matches the lower end of the blade-side cutting surface **64**A, the inclined surface **64**C is inclined to the one side in the rotation direction of the rotation body **44** as going upward when seen from the radial direction of the rotation body **44**.

Regarding Needle Plate **70**

As illustrated in FIGS. **1** and **3**, the needle plate **70** is formed in a substantially rectangular plate shape of which the plate thickness direction is the up-down direction. The needle plate **70** is detachably fixed to the upper portion of the bed portion **12**C of the sewing machine body **12**, and is arranged below the cutwork mechanism **30**. The cutting target object **90** sandwiched by the embroidery frame **22** is placed above the needle plate **70** (refer to FIG. **4**).

A plurality of (**16** in the embodiment) needle plate holes **72** are formed to penetrate the needle plate **70**. The plurality of needle plate holes **72** are arranged on a reference circle C which is around the axis line AL of the needle bar **16** and has a radius R, in a plan view. Further, the needle plate holes **72** are arranged at equal intervals (every 22.5 degrees) around the axis line AL (rotation direction of the rotation body **44**). That is, the plurality of needle plate holes **72** are arranged along the rotation direction of the cutwork blade (rotation body **44**). The distance L from the axis line AL to the cutwork blade **60** and the distance from the axis line AL to the needle plate hole **72** (that is, the radius R of the reference circle C) are the same.

Further, the plurality of needle plate holes **72** are arranged at positions corresponding to the blade-side rotation positions of the cutwork blade **60**. In other words, the positions of the plurality of needle plate holes **72** are set such that the cutwork blade **60** held at the blade-side rotation position is arranged to face any of the needle plate holes **72** of the needle plate **70** in the up-down direction.

In addition, the needle plate hole **72** is formed in a shape corresponding to the blade portion **64** of the cutwork blade **60**. Specifically, the needle plate hole **72** is formed in a substantially D shape similar to that of the blade portion **64** in a plan view, and the outer shape of the needle plate hole **72** is set to be slightly greater than the outer shape of the blade portion **64**. More specifically, the needle plate hole **72** is configured to include a hole-side cutting surface **72**A which corresponds to the blade-side cutting surface **64**A of the blade portion and extends linearly in the radial direction of the rotation body **44** in a plan view, and a hole-side curved surface **72**B which corresponds to the blade-side curved surface **64**B of the blade portion **64** and is curved in a substantially arc shape to be convex to one side (direction of the arrow A in FIG. **3**) of the rotation direction of the rotation body **44** in a plan view. In this manner, the directions the needle plate hole **72** and the blade portion **64** which are arranged to face each other in the up-down direction match each other in a plan view.

When the cutwork blade **60** is lowered together with the needle bar **16**, the blade portion **64** of the cutwork blade **60** is inserted into the needle plate hole **72** so that the cutting target object **90** is cut. Specifically, when the blade portion **64** is inserted into the needle plate hole **72**, the blade-side cutting surface **64**A of the blade portion **64** and the hole-side cutting surface **72**A of the needle plate hole **72** are arranged to face each other in a state where there is almost no gap in the rotation direction of the rotation body **44**. In this manner, the cutting target object **90** is sheared by the blade-side cutting surface **64**A of the blade portion **64** and the hole-side cutting surface **72**A of the needle plate hole **72** so that the cutting target object **90** is cut.

It is sufficient that the needle plate hole **72** is formed in a non-circular shape including at least the hole-side cutting surface **72**A corresponding to the blade portion **64** of the cutwork blade **60** in a plan view. Therefore, the expression "the blade portion is inserted into the needle plate hole in a state where the direction of the needle plate hole matches the blade portion of the cutwork blade" in the invention refers to that the blade portion **64** is inserted into the needle plate hole **72** such that the blade-side cutting surface **64**A of the blade portion **64** and the hole-side cutting surface **72**A of the needle plate hole **72** face each other.

Regarding Presser **80**

As illustrated in FIGS. **1** and **4**, the presser **80** is configured to include a presser plate portion **82**, and a presser fixing portion **84**. The presser plate portion **82** is formed in a substantially disk shape of which the plate thickness direction is the up-down direction. The presser fixing portion **84** is formed in a substantially L-shaped block shape when seen from the left side, and the lower end portion of the presser fixing portion **84** is connected to the rear end portion of the presser plate portion **82**. The upper end portion of the presser fixing portion **84** is fixed to the lower end portion of the presser bar **14** by a fixing screw S**2**. The presser **80** is moved downward together with the presser bar **14** by operating the operation lever (not illustrated) so as to press the cutting target object **90** from above.

Further, a plurality of (**16** in the embodiment) insertion holes **82**A are formed to penetrate the presser plate portion **82**, at positions corresponding to the needle plate holes **72** of the needle plate **70**. The insertion hole **82**A is formed to have a substantially D-shaped cross section similar to that of the needle plate hole **72**. The inner circumferential surface of the insertion hole **82**A is inclined inward of the insertion hole **82**A as going downward. That is, the size of the outer shape of the insertion hole **82**A is set to be decreased as going downward. Further, the outer shape of the lower end of the insertion hole **82**A is set to be greater than the outer shape of the needle plate hole **72**. When the needle bar **16** is lowered, the blade portion **64** of the cutwork blade **60** is inserted through the insertion hole **82**A while being guided by the inner circumferential surface of the insertion hole **82**A, and is inserted into the needle plate hole **72** from above (refer to FIG. **4**).

Action and Effect

In the sewing machine **10** configured as described above, the base **42** is attached to the lower end portion of the needle bar **16**, and the rotation body **44** is connected to the base **42** to be rotatable around the axis line AL of the needle bar **16**. The rotation body **44** is provided with the cutwork blade **60**, and the cutwork blade **60** extends downward from the rotation body **44** at a position eccentric from the axis line AL

by the distance L. Further, at the rotation body lock position of the rotation body **44**, the rotation of the rotation body **44** is restricted by the lock mechanism **50**, and the cutwork blade **60** is held at any of the plurality of blade-side rotation positions.

The needle plate **70** is provided below the rotation body **44**. The plurality of needle plate holes **72** into which the blade portion **64** of the cutwork blade **60** is inserted are formed in the needle plate **70**, and the plurality of needle plate holes **72** are arranged along the rotation direction of the cutwork blade **60** (rotation body **44**). Specifically, the plurality of needle plate holes **72** are arranged at positions respectively corresponding to the plurality of blade-side rotation positions of the cutwork blade **60**. More specifically, the plurality of needle plate holes **72** are arranged directly below the cutwork blade **60** arranged at the blade-side rotation position, and the cutwork blade **60** (blade portion **64**) and the needle plate hole **72** are arranged to face each other in the up-down direction. In this manner, when the needle bar **16** is lowered so that the blade portion **64** is inserted into the needle plate hole **72**, the cutting target object **90** placed above the needle plate **70** is cut by the blade portion **64** and the needle plate hole **72**.

Here, in the needle plate **70**, the plurality of needle plate holes **72** are formed in a shape corresponding to the shape of the blade portion **64**, and the direction of each of the needle plate holes **72** matches the direction of the blade portion **64** which is arranged to face the needle plate hole in the up-down direction. Specifically, the needle plate hole **72** has the hole-side cutting surface **72**A corresponding to the blade-side cutting surface **64**A of the blade portion **64**, and the blade-side cutting surface **64**A and the hole-side cutting surface **72**A are formed in a flat surface shape. Further, the direction of the needle plate hole **72** is set such that the blade-side cutting surface **64**A and the hole-side cutting surface **72**A face each other when the blade portion **64** is inserted into the needle plate hole **72**. In this manner, when the cutting target object **90** is cut by the blade portion **64** and the needle plate hole **72**, the cutting target object **90** can be sheared and cut by the blade-side cutting surface **64**A and the hole-side cutting surface **72**A. As a result, the finish of the cut portion of the cutting target object **90** can be improved.

That is, for example, in the sewing machine described in the background art (hereinafter, this sewing machine is referred to as a sewing machine in a comparative example), the cutwork blade is arranged coaxially with the needle bar, and the cutwork blade is rotated around the axis of the needle bar at every predetermined rotation angle. Therefore, in the sewing machine of the comparative example, in a case where the cutwork blade is rotated around the axis of the needle bar at every predetermined rotation angle, the cutwork blade is rotated around the axis of the needle bar relative to the needle plate in a state where the position of the cutwork blade relative to the needle plate is not changed. That is, the direction of the blade portion with respect to the needle plate is changed in a state where the position of the blade portion of the cutwork blade relative to the needle plate is not changed.

Therefore, in the sewing machine of the comparative example, in order to prevent the interference between the blade portion and the needle plate hole when the blade portion of the cutwork blade is inserted into the needle plate hole, for example, it is necessary to form the needle plate hole in a relatively large round shape. That is, in the needle plate hole, the hole-side cutting surface having a flat surface shape which corresponds to the blade-side cutting surface of the blade portion cannot be formed. In this manner, in the sewing machine of the comparative example, the cutting target object **90** cannot be sheared to be cut by the blade portion and the needle plate hole, and thus the blade portion performs cutting by tearing off the cutting target object **90**. Therefore, the cut portion of the cutting target object **90** may become a rough surface.

On the other hand, in the sewing machine **10** of the first embodiment, the cutwork blade **60** is configured to be rotatable around the axis line AL of the needle bar **16**, and is arranged at a position apart from the axis line AL by the distance L. Therefore, when the cutwork blade **60** is rotated around the axis line AL, the position of the cutwork blade **60** relative to the needle plate **70** is changed, and the direction of the blade portion **64** with respect to the needle plate **70** is changed. In this manner, in the sewing machine **10** of the first embodiment, by forming a plurality of the needle plate holes **72**, which respectively correspond to the blade-side rotation positions of the cutwork blade **60**, in the needle plate **70**, the cutwork blade **60** arranged at the blade-side rotation position and the needle plate hole **72** can have a one-to-one correspondence. That is, each needle plate hole **72** has a shape corresponding to the blade portion **64**, and the direction of each needle plate hole **72** can match the direction of the blade portion **64** arranged to face the needle plate hole in the up-down direction. As a result, as described above, when the cutting target object **90** is cut by the blade portion **64** and the needle plate hole **72**, the cutting target object **90** can be sheared and cut by the blade-side cutting surface **64**A and the hole-side cutting surface **72**A. Accordingly, the finish of the cut portion of the cutting target object **90** can be improved.

The cutwork mechanism **30** has the lock mechanism **50**, and the rotation body **44** is locked at every predetermined rotation angle by the lock mechanism **50**. The cutwork blade **60** is provided on the rotation body **44** at a position apart from the axis line AL by the distance L. Further, the plurality of needle plate holes **72** are formed in the needle plate **70**. The plurality of needle plate holes **72** are arranged on the reference circle C which is around the axis line AL and has a radius R, and the radius R and the distance L are set to be the same. In this manner, by forming, in the needle plate **70**, the needle plate holes **72** of which the directions match the cutwork blade **60** held at the plurality of blade-side rotation positions eccentric with respect to the axis line AL, cutwork can be performed on the cutting target object **90**.

The blade portion **64** of the cutwork blade **60** has the blade-side cutting surface **64**A that is linearly formed when seen from below, and the needle plate hole **72** has the hole-side cutting surface **72**A having a flat surface shape corresponding to the blade-side cutting surface **64**A. Specifically, the needle plate hole **72** has the hole-side cutting surface **72**A arranged to face the rotation direction of the cutwork blade **60** when the blade portion **64** is inserted into the needle plate hole **72**. In this manner, as described above, when the cutting target object **90** is cut by the blade portion **64** and the needle plate hole **72**, the cutting target object **90** can be sheared and cut by the blade-side cutting surface **64**A and the hole-side cutting surface **72**A. Accordingly, the finish of the cut portion of the cutting target object **90** can be improved.

Second Embodiment

Hereinafter, a sewing machine **100** according to a second embodiment will be described using FIGS. **5** and **6**. The sewing machine **100** of the second embodiment is config-

ured similar to the sewing machine **10** of the first embodiment except the following points. In FIGS. **5** and **6**, the portions configured similar to the sewing machine **10** are denoted by the same reference numerals.

That is, in the second embodiment, the needle plate **70** is configured to include a needle plate body **74**, and a rotary needle plate **76**. Further, a needle plate lock mechanism **110** is provided in the needle plate **70**. Hereinafter, the configurations of the needle plate **70** and the needle plate lock mechanism **110** in the second embodiment will be described.

Regarding Needle Plate Body **74**

The needle plate body **74** is formed in a substantially rectangular plate shape of which the plate thickness direction is the up-down direction, and is detachably fixed to the upper portion of the bed portion **12**C of the sewing machine body **12**, on a side below the cutwork mechanism **30**. In the needle plate body **74**, an exposure hole **74**A for exposing the rotary needle plate **76** which will be described later is formed below the needle bar **16** to penetrate the needle plate body **74**, and the exposure hole **74**A is formed in a circular shape and is arranged coaxially with the needle bar **16**.

Further, in the needle plate body **74**, an accommodation groove **74**B for accommodating a needle plate lock member **112** which will be described later is formed on the front side of the exposure hole **74**A. The accommodation groove **74**B extends in the front-rear direction (radial direction of the exposure hole **74**A) in a plan view, and the rear end portion of the accommodation groove **74**B communicates with the exposure hole **74**A.

Regarding Rotary Needle Plate **76**

The rotary needle plate **76** is formed in a substantially disk shape of which the plate thickness direction is the up-down direction. The rotary needle plate **76** is inserted into the exposure hole **74**A of the needle plate body **74**, and is rotatably supported by the exposure hole **74**A. In this manner, the rotary needle plate **76** is connected to the needle plate body **74** so as to be rotatable around the axis line AL. A flange (not illustrated) protruding outward in the radial direction is formed in the outer circumferential portion of the rotary needle plate **76**, and this flange is arranged adjacent to the lower side of the edge portion of the exposure hole **74**A. In this manner, the upward movement of the rotary needle plate **76** is restricted. Further, the rotary needle plate **76** is urged upward by a plate spring (not illustrated) provided on the needle plate body **74**. In this manner, the downward movement of the rotary needle plate **76** is restricted.

A plurality of (**16** in the embodiment) lock grooves **76**A are formed on the outer circumferential portion of the rotary needle plate **76**. The lock groove **76**A is formed in a substantially V shape open outward in the radial direction of the rotary needle plate **76**, and the lock grooves **76**A are arranged at equal intervals (every 22.5 degrees) in the circumferential direction of the rotary needle plate **76**. The lock grooves **76**A constitute a part of the needle plate lock mechanism **110** which will be described later.

One needle plate hole **72** is formed to penetrate the rotary needle plate **76**, at a portion on the outer circumferential side of the rotary needle plate **76**. Similar to the first embodiment, the needle plate hole **72** is formed on the reference circle C which is around the axis line AL and has a radius R. Further, similar to the first embodiment, the needle plate hole **72** is configured to include the hole-side cutting surface **72**A which extends in the radial direction of the rotation body **44**, and the hole-side curved surface **72**B which is curved to be convex to one side of the rotation direction of the rotation body **44**.

Regarding Needle Plate Lock Mechanism **110**

The needle plate lock mechanism **110** is configured to include the lock grooves **76**A formed in the above-described rotary needle plate **76**, the needle plate lock member **112**, and an urging spring **114**.

The needle plate lock member **112** is formed in a substantially long plate shape of which the plate thickness direction is the up-down direction and which extends in the front-rear direction. The needle plate lock member **112** is inserted into the accommodation groove **74**B of the needle plate body **74** so as to be relatively movable in the front-rear direction. A flange (not illustrated) protruding to both sides in the left-right direction is formed in the left and right outer circumferential portions of the needle plate lock member **112**, and this flange is arranged adjacent to the lower side of the edge portion of the accommodation groove **74**B. In this manner, the upward movement of the needle plate lock member **112** is restricted. Further, the needle plate lock member **112** is urged upward by a plate spring (not illustrated) provided on the needle plate body **74**. In this manner, the flange of the needle plate lock member **112** is in contact with the lower surface of the needle plate body **74**, and the needle plate lock member **112** is held by the needle plate body **74**.

The rear end portion of the needle plate lock member **112** is configured as an engaging portion **112**A. The engaging portion **112**A is formed in a substantially V shape, which is convex rearward in a plan view, corresponding to the lock grooves **76**A of the rotary needle plate **76**.

The urging spring **114** is configured as a compression coil spring. The urging spring **114** is accommodated in the accommodation groove **74**B together with the needle plate lock member **112** in a state of being compressed and deformed. Specifically, one end portion of the urging spring **114** is locked to the front end portion of the needle plate lock member **112**, and the other end portion of the urging spring **114** is locked to the bottom portion of the accommodation groove **74**B, so that the needle plate lock member **112** is urged rearward (toward the rotary needle plate **76**) by the urging spring **114**.

The engaging portion **112**A of the needle plate lock member **112** is inserted into the lock groove **76**A of the rotary needle plate **76** to be engaged with the lock groove **76**A, and thereby the rotation of the rotary needle plate is locked (prevented) by the needle plate lock mechanism **110**. Hereinafter, the position of the rotary needle plate **76** locked (prevented) by the needle plate lock mechanism **110** is referred to as a needle plate lock position.

Further, the lock state of the rotary needle plate **76** by the needle plate lock mechanism **110** is released by applying rotational force equal to or greater than a predetermined value to the rotary needle plate **76**. That is, by applying the rotational force equal to or greater than the predetermined value to the rotary needle plate **76**, the needle plate lock member **112** is moved forward against the urging force of the urging spring **114**, and thereby the engaged state between the needle plate lock member **112** and the lock groove **76**A is released. Then, the needle plate lock member **112** is engaged with the lock groove **76**A again when the rotary needle plate **76** is rotated to the next needle plate lock position, and thereby the rotary needle plate **76** returns to the lock state by the needle plate lock mechanism **110**. That is, the rotary needle plate **76** is configured to be locked at every predetermined rotation angle (22.5 degrees in the embodiment) by the needle plate lock mechanism **110**. In other words, the rotation angle at which the rotation body **44** is

locked by the lock mechanism **50** matches the rotation angle at which the rotary needle plate **76** is locked by the needle plate lock mechanism **110**.

The position of the needle plate hole **72** with respect to the rotary needle plate **76** around the axis line AL is set such that the needle plate hole **72** and the cutwork blade **60** (blade portion **64**) held at the blade-side rotation position are arranged to face each other in the up-down direction, at the needle plate lock position of the rotary needle plate **76**. That is, by rotating the rotary needle plate **76** to the needle plate lock position according to the blade-side rotation position of the cutwork blade **60** (rotation body lock position of the rotation body **44**), the needle plate hole **72** and the cutwork blade **60** (blade portion **64**) are arranged to face each other in the up-down direction.

As described above, the needle plate hole **72** is configured to include the hole-side cutting surface **72**A which extends in the radial direction of the rotation body **44**, and the hole-side curved surface **72**B which is curved to be convex to one side of the rotation direction of the rotation body **44**. Therefore, by aligning the needle plate lock position of the rotary needle plate **76** and the rotation body lock position of the rotation body **44** such that the needle plate hole **72** and the cutwork blade **60** (blade portion **64**) are arranged to face each other in the up-down direction, the blade portion **64** can be inserted into the needle plate hole **72** in a state where the direction of the blade portion **64** of the cutwork blade **60** matches the direction of the needle plate hole **72**. Accordingly, similar to the first embodiment, the finish of the cut portion of the cutting target object **90** can be improved even in the second embodiment.

Further, in the second embodiment, the needle plate **70** is configured to include the rotary needle plate **76** and the needle plate body **74**, and the rotary needle plate **76** is rotatably supported by the needle plate body **74**. In addition, the rotary needle plate **76** is locked at every predetermined rotation angle to be held at the needle plate lock position by the needle plate lock mechanism **110**. In this manner, even in a case where one needle plate hole **72** is formed in the needle plate **70**, the blade portion **64** can be inserted into the needle plate hole **72** in a state where the direction of the blade portion **64** of the cutwork blade **60** matches the direction of the needle plate hole **72**.

Third Embodiment

Hereinafter, a sewing machine **200** according to a third embodiment will be described using FIG. **7**. The sewing machine **200** of the third embodiment is configured similar to the sewing machine **100** of the second embodiment except the following points. In FIG. **7**, the portions configured similar to the sewing machine **100** are denoted by the same reference numerals.

That is, in the sewing machine **200** of the third embodiment, the cutwork blade **60** is fixed to the rotation body **44**, at a position coaxial with the needle bar **16**. That is, the fixing hole **44**C of the rotation body **44** (not illustrated in FIG. **7**) is formed at the central portion of the rotation body **44**. In this manner, at each blade-side rotation position of the cutwork blade **60**, the position of the blade portion **64** relative to the rotary needle plate **76** is not changed, but the direction of the blade portion **64** relative to the rotary needle plate **76** is changed.

In addition, in the third embodiment, the needle plate hole **72** is formed at the central portion of the rotary needle plate **76**, corresponding to the position of the cutwork blade **60**. That is, the needle plate hole **72** and the cutwork blade **60** (blade portion **64**) are arranged to face each other in the up-down direction. Further, the position of the needle plate hole **72** with respect to the rotary needle plate **76** around the axis line AL is set such that the direction of the needle plate hole **72** at the needle plate lock position of the rotary needle plate **76** matches the direction of the blade portion **64** of the cutwork blade **60** at any of the blade-side rotation positions. That is, in the third embodiment, the directions of the blade portion **64** and the needle plate hole **72** match each other by rotating the rotary needle plate **76**.

In this manner, by rotating the rotary needle plate **76** to the predetermined needle plate lock position such that the direction of the needle plate hole **72** and the direction of the blade portion **64** of the cutwork blade **60** match each other, the blade portion **64** can be inserted into the needle plate hole **72** in a state where the blade-side cutting surface **64**A of the blade portion **64** and the hole-side cutting surface **72**A of the needle plate hole **72** are arranged to face each other. Accordingly, similar to the first and second embodiments, the finish of the cut portion of the cutting target object **90** can be improved even in the third embodiment.

Further, in the third embodiment, the cutwork blade **60** is arranged coaxially with the needle bar **16**. In this manner, pressing force applied from the needle bar **16** to the cutwork blade **60** when the cutting target object **90** is cut by the cutwork blade **60** can be efficiently applied to the cutting target object **90**. In this manner, the finish of the cut portion of the cutting target object **90** can be further improved.

In the third embodiment, the insertion hole **82**A of the presser **80** is formed at the central portion of the presser plate portion **82**, corresponding to the position of the cutwork blade **60**. In addition, the insertion hole **82**A is formed in a circular shape into which the blade portion **64** of the cutwork blade **60** can be inserted.

Regarding Modification Example of Shapes of Blade Portion **64** of Cutwork Blade **60** and Needle Plate Hole **72**

As illustrated in FIG. **8**A, in Modification Example 1, the blade portion **64** of the cutwork blade **60** is formed in a shape similar to that in the first to third embodiments. On the other hand, the needle plate hole **72** is formed in a substantially track shape in a plan view. That is, the needle plate hole **72** is configured by the hole-side cutting surface **72**A, a first inner circumferential surface **72**C arranged parallel to the hole-side cutting surface **72**A, and a pair of second inner circumferential surfaces **72**D which are curved in an arc shape connecting the hole-side cutting surface **72**A and the first inner circumferential surface **72**C. Even in this case, when the blade portion **64** is inserted into the needle plate hole **72**, the hole-side cutting surface **72**A and the blade-side cutting surface **64**A are arranged to face each other by matching the direction of the needle plate hole **72** with the direction of the blade portion **64**, and thus the finish of the cut portion of the cutting target object **90** can be improved.

As illustrated in FIG. **8**B, in Modification Example 2, the blade portion **64** of the cutwork blade **60** is formed to have a substantially track-shaped section. Specifically, the blade portion **64** is configured by the blade-side cutting surface **64**A, a first outer circumferential surface **64**D arranged parallel to the blade-side cutting surface **64**A, and a pair of second outer circumferential surfaces **64**E which are curved in an arc shape connecting the blade-side cutting surface **64**A and the first outer circumferential surface **64**D. The needle plate hole **72** in Modification Example 2 is formed in a substantially track shape in a plan view, similar to the needle plate hole **72** in Modification Example 1. That is, the needle plate hole **72** is configured by the hole-side cutting surface **72**A, the first inner circumferential surface **72**C

arranged parallel to the hole-side cutting surface **72**A, and the pair of second inner circumferential surfaces **72**D which are curved in an arc shape connecting the hole-side cutting surface **72**A and the first inner circumferential surface **72**C. Even in this case, when the blade portion **64** is inserted into the needle plate hole **72**, the hole-side cutting surface **72**A and the blade-side cutting surface **64**A are arranged to face each other by matching the direction of the needle plate hole **72** with the direction of the blade portion **64**, and thus the finish of the cut portion of the cutting target object **90** can be improved.

The first to third embodiments can be variously omitted, replaced, and changed without departing from the scope of the invention, and the modifications thereof are also included in the invention.

What is claimed is:

1. A sewing machine comprising:

a rotation mechanism configured to include

a base attached to a lower end portion of a needle bar that is moved up and down, and

a rotation body connected to the base to be rotatable around an axis of the needle bar;

a cutwork blade which is provided on the rotation body, and extends downward from the rotation body; and

a needle plate which is provided below the rotation mechanism, and has a needle plate hole for cutting a cutting target object in cooperation with a blade portion of the cutwork blade when the blade portion is inserted into the needle plate hole,

wherein:

the blade portion of the cutwork blade has a blade-side cutting surface, and the needle plate hole has a hole-side cutting surface corresponding to the blade-side cutting surface:

an axis line of the cutwork blade moves along a rotating direction of the rotation body with respect to the needle plate hole; and

the blade portion is inserted into the needle plate hole in a state where the hole-side cutting surface of the needle plate hole fits the blade-side cutting surface of the blade portion of the cutwork blade.

2. The sewing machine according to claim **1**,

wherein the rotation body is locked at a predetermined rotation angle by a lock mechanism,

the cutwork blade is arranged at a position apart from an axis line of the needle bar, and

a plurality of needle plate holes are formed around the axis line of the needle bar at the same angle as the predetermined angle of the lock mechanism, on a reference circle having, as a radius, the same distance as a distance between the axis line of the needle bar and the cutwork blade.

3. The sewing machine according to claim **1**,

wherein the rotation body is locked at a predetermined rotation angle by a lock mechanism, and

the needle plate is configured to include

a needle plate body fixed to the sewing machine body, and

a rotary needle plate which is connected to the needle plate body to be rotatable around the axis of the needle bar, and is able to be locked at every angle that is the same as the predetermined angle of the lock mechanism, and in which the needle plate hole is formed.

4. The sewing machine according to claim **3**,

wherein the cutwork blade is arranged coaxially with the needle bar.

5. The sewing machine according to claim **3**,

wherein the cutwork blade and the needle plate hole are arranged at positions apart from an axis line of the needle bar by the same distance.

6. The sewing machine according to claim **1**,

wherein the blade-side cutting surface of the blade portion is linearly formed when seen from an axial direction of the needle bar, and

the hole-side cutting surface of the needle plate hole is formed in a flat surface shape.

* * * * *